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ON THE FEASIBILITY OF RAISING SPONGES FROM THE EGG*

H. V. WILSON.

For the purposes of scientific investigation the problem suggested in the title of this paper presents no difficulties to the zoologist. Whether, on the other hand, it is practicable or even desirable to rear sponges from the egg for the purposes of the sponge-grower, is a question which can only be decided by experiments carried on continuously for some years. From the standpoint of the scientific breeder such experiments seem eminently desirable, and the probability that they would result in economic discoveries of importance is very great. It is my purpose to point out, toward the end of this paper, some of the advantages attainable, as I believe, by this method of breeding. I shall preface my remarks on the rearing of sponges with a brief account of the manner in which the egg development goes on.

*Extracted from "Proceedings and Papers of the National Fishery Congress held at Tampa, Fla., Jan. 1898," published in Bulletin of U. S. Fish Commission, Washington, 1898.

Some sponges are known to be hermaphrodite, others have been described as of separate sexes. The probability is that sponges are in general hermaphrodite, but that the individual at one period produces chiefly male elements, and later chiefly female elements. Fertilization takes place in the body of the mother and the egg here undergoes early development. The embryo eventually bursts the maternal tissue, and, passing into one of the canals, is caught by the current sweeping through the canal system and is discharged into the surrounding water through one of the large apertures (oscula) on the surface of the sponge.

In the great majority of sponges (horny and silicious forms) the embryo, or larva as it now should properly be called since it leads a free life, is an oval, solid body, covered with slender hair-like processes of protoplasm, the so-called cilia. The cilia strike rythmically to and fro, like so many minute and flexible paddles, and the sponge larva is by their means whirled through the water. Sponge larvae, of course, vary in size, but frequently have a length in the neighborhood of 1 mm, (.04 inch). The surface layer contains more or less pigment. Thus in the commercial sponge, *Euspongia*, the larva is whitish, with a brown spot at one end. In *Tedani brucei*, a large red sponge, growing especially on the mangroves in parts of the Bahamas, the larva is a beautiful red.

The free swimming life of the sponge larva is short lasting, when bred in the laboratory, only a day or two. During this period the larva is moved not only by its own relatively feeble motion, but, being subject to the action of the currents, it may be carried a considerable distance from the spot where it was born. It eventually settles down on some firm basis and transforms. The cilia are lost, and the oval body flattens out into a disk so thin that it

has the appearance of a minute incrustation. The circular outline of the disk is soon lost, the little sponge spreading in an irregular fashion over the surface to which it is now firmly attached. In two or three days the metamorphosis is complete, and we have a sponge, very small to be sure, and without reproductive elements, but like the adult in fundamental structure. Its surface is perforated by minute apertures, the pores, through which the water enters the body, and by a few larger apertures, the oscula, through which the water leaves the body. Ramifying through the interior is a system of spaces or canals which connect the pores with the oscula. Portions of this canal system form spheroidal chambers, the walls of which are studded with cilia. It is owing to the motion of these internal unseen cilia that a current of water is constantly circulating through the sponge body, carrying to its tissues the oxygen and food (minute particles of animal and vegetable organisms) necessary for their life.

How long it takes for a sponge developed in this way to reach adult size and begin breeding is unknown. I have kept young sponges that have transformed and attached to the walls of my laboratory aquaria for days and weeks. After the first few days the increase in size has generally been imperceptible. But the unfavorable conditions incidental to such an unnatural habitat were doubtless responsible for this lack of success.

PRACTICAL SUGGESTIONS ON REARING SPONGES

More species of sponges breed during the warm season than at other times. Yet in the Mediterranean (Naples) some sponges are found breeding at all times of the year. In the Bahama Islands and on our own coast, I have found the breeding time of many sponges to fall within the period from midsummer on through early autumn. For

the inauguration of experiments I should reccommend the months of July, August, and September.

It is easy to determine when one of the horny or silicious sponges is breeding. On cutting out a piece of the sponge, the developing eggs scattered though the tissues can be seen without the help of a lens. They are minute, rounded bodies, often very numerous, and sufficiently conspicuous to catch an observant eye.

The means employed for getting young sponges must always be different from those made use of in the case of animals like fish, oysters, etc., in which artificial fertilization is practicable. Since the sponge egg is fertilized and undergoes its early development in the body of the mother, artificial fertilization is here of course out of the question.

The young in numbers ample for study can, however, be obtained in the following easy manner. The sponge being raised to near the surface of the water is then dipped up in a glass aquarium or bucket, in such a way as not to expose the animal to the air. In a few minutes time the ciliated larvae will begin to be discharged. In the study of some Bahama sponges I found it convenient to take to the sponge-grounds, in a boat, a couple of good sized tubs. In one of these some sponges would be placed for about half an hour. At the end of that time they were transferred to the second tub. The water of the first tub was meanwhile examined for the sponge larvae. In this I was aided by negro boys, who soon became expert. We bailed out the water in 2-gallon glass vessels in which the little larvae could readily be seen. The latter were then picked out with glass tubes and placed in a special dish. By the time the examination of the first tub was completed, the second would be found to contain numbers of larvae. These were collected in the same way, the sponges being thrown overboard.

It would seem in the case of sponges, as with so many marine animals, that the stimuli arising from confienment in a limited volume of water lead to the rather sudden discharge of those embryos (or in certain forms, eggs) that have reached the proper stage for birth.

I have no doubt that if the sponge were handled carefully, it would be possible to get from the same individual, day after day dnring the breeding season, numbers of larvae, precisely as several batches of eggs are got from one codfish, for example.

The swimming larvae thus obtained may be made to attach, during the next day or two, to the walls of the dishes in which they are kept, or to pieces of wood or small stones. After attachment the young, or, as we might say, the sponge "spat," are easy to handle. In this connection, however, it will be well to bear in mind that the circulating pipe water of aquaria, even large and elaborate ones such as those at Naples and Woods Holl, has been found to be unsatisfactory for the rearing of young sponges, as indeed it is for the young stages of many marine organism. The sponges become covered with sediment, and bacteria develop. Changing the water in the dishes twice a day is, on the whole, a better method. But this is far from an ideal environment. It will probably be much better, after the attachment of the spat to pieces, of wood, shells, etc., at once to transfer the latter to some natural site known to be adapted to the growth of sponges.

I hardly think the method of getting young sponges which I have just described can ever be adaptedto the needs of the sponge-grower. And yet for the purposes of experiment, where a few hundreds or a thousand young sponges would suffice, the method is adequate. I believe, however, that live-boxes may be devised in which the sponge may be kept imprisoned in its natural home,

though at some convenient depth, and in which the discharge of larvae may go on normally day after day. Such a box must have fine metal gauze windows on the sides and above, through which water may pass freely, and yet with meshes sufficiently fine at any rate to hinder the passage of the larvae through them. Projecting shelves, which must be easily removable, might be arranged one above the other. The sides and bottom of the box should, moreover, be covered with removable pieces—tiles, for instance. The larvae settling down on the removable shelves or other pieces would attach to them, and might from time to time be taken out with as much ease as the honey stored up in the modern manufactured comb; is removed from the hive.

The precise form of live-box to be used will naturally only be determined after proper experiments. To prevent as far as possible the settling of the larvae on the body of the mother, a phenomenon very apt to occur, it will perhaps be found well to place the adult on a perforated tray near the top of the box, and a series of such trays, one above the other, may be found a good device. In planning experimental boxes of this sort, the character of the motion of the sponge larva should be borne in mind. The larva not only swims, frequently making long, shallow dives, but also creeps about over the sides and bottom of the vessel in which it is kept.

The live-box has proved itself of great use to the naturalist desirous of obtaining the young stages of animals, which are difficult to keep or breed in the laboratory. In this connection I well remember the experience of a companion (Prof. C. L. Edwards), engaged in the study of the development of the large holothurian or sea-cucumber (Mülleria), so common in parts of the Bahama Islands. It was with the greatest difficulty that a few embryos of this form could be got in the laboratory.

When, however, the animals were confined in a large box anchored in about a fathom of water, quantities of developing eggs could be had by drawing up with a tube some of the sediment in the bottom of the box.

The "spat" ouce obtained in abundance, success will next depend largely on the selection of the locality in which the young sponges are to be set out. A careful study of the Florida grounds should be undertaken, with the view of investigating, among other points, this very matter of the kinds of locality best adapted to the growth of the various grades of sponges. Quiet water, a firm bottom, and an absence of muddy sediment seem essential desiderata. The question of enemies is probably of minor importance, and yet the well-known student of sponges, Vosmaer, mentions that he has several times seen the European hermit-crab(*Pagurus*)greedily eat a common silicious sponge (*Suberites*), certainly quite as unappetizing a morsel as the commercial sponge.

When it has once been accurately determined what are the physical and biological characteristics of the Florida grounds, which produce the finest sponges—and it may be mentioned here that sponges are among the most variable of animals and seem to be peculiarly affected by their surroundings—a detailed comparison should be made between these grounds and those parts of the Mediterranean producing the finest grades. The purpose ofsuch a comparison would be to discover whether we really lack any of the natural advantages necessary for the production of the finest sponges, and if so, whether these can be artificially reproduced—whether for instance it would be possible or desirable to imitate on this side a particular kind of bottom found in the Mediterranean.

Following on the investigation of the sponge-grounds,

I believe it to be eminently desirable to start a series of of experiments, the purpose of which shall be to discover how far, along what lines, and by what means sponges may be artificially altered by breeding. The great variability of sponges in nature leads one to believe that they would quickly respond as individuals to a change in the environment, and thus, simply by growing the animals in a superior locality, an improved variety, constant, as long as the sponges continue to grow in that locality, might be produced. It is quite likely that such improvements could be carried out on sponges propagated by cuttings as well as on those grown from eggs. In improving races, however, it has always been found that the two important means are sexual breeding from selected specimens, and grafting, the latter method being commonly regarded as only applicable to plants.

In the case of sponges, as in that of other organisms, increase of knowledge will in all probability confirm the belief already fairly well grounded, that individuals developed from the fertilized eggs vary more, i. e., exhibit more differences one from the other, than individuals grown from buds or cuttings. Herein, to my mind, lies the advisability of growing sponges from eggs as well as from cuttings. The latter method, being quick, sure, and simple, can at once be made of great practical use. Breeding from the egg is more complex, and must be carefully tried by competent experimenters. In the end, however, I believe that it will lead to great improvements in the quality of our sponges.

I would suggest that, after selection of a proper locality, a small plantation of sponges developed from eggs be started and carefully watched. As the sponges grow, it would be a simple matter to pick out those individuals in which the fiber varied in the desired direction. A small

piece cut out would not seriously injure the sponge, and would show the quality of fiber as well as the entire body. Selected individuals might be removed from the general ground and during the breeding season placed together in large live boxes. The "spat" collected from such individuals would doubtless develop into superior sponges. I do not know any marine animals which would seem to be so adapted to continuous rearing, with constant improvement of breed, as sponges. Their plant-like habit of growth make it easy to handle and experiment upon them. Their variability, especially in the matter of the skeleton, would seem to insure success to selective breeding; and the very simplicity of what is desired, namely, improvement in the quality of the skeletal fiber, would at once lend a directness to the cultivator, which should lead to comparatively early results.

In closing, I may direct your attention to a method of race improvement, so far practiced only in the cultivation of plants, but to which the vegetative character of sponges will readily lend itself. I refer to the method of grafting. The ease with which two or more individuals of the same species of sponge, irrespective of age, may be made to fuse, and become henceforth a single individual, is well known. Dr. Grant records observations on this head as far back as 1826. Among later experimenters I will only mention Vosmaer. This fusion of individuals goes on commonly in nature. An interesting account of a number of cases may be read in Johnston's British Sponges and Corallines, published 1842, page 11.

The natural tendency of sponges to grow together, coupled with the ease with which they may be propagated by cuttings, would make artificial grafting in these animals a simple matter. With a small plantation of very superior sponges at hand, the result of careful breeding from selected individuals, and other plantations consisting fo

sponges grown from cuttings, grafting ought to be not only a scientific but an economic success. At slight expense large numbers of common sponges might be improved, simply by pinning to the common cutting a piece of the improved varietv.

A REVIEW OF CONANT'S MEMOIR ON THE CUBOMEDUSÆ*

H. V. WILSON.

Memoirs from the Biological Laboratory of the Johns Hopkins University, IV., 1. *The Cubomedusæ*. A Dissertation presented for the Degree of Doctor of Philosophy, in the Johns Hopkins University, 1897. By FRANKLIN STORY CONANT. A Memorial Volume. Baltimore, 1898.

The late Dr. Conant, it will be recalled by many, was a member of the marine laboratory of the Johns Hopkins University, stationed during the summer of 1897 at Port Antonio, Jamaica. Toward the end of the season's work fever broke out. The director of the expedition, Dr. J. E. Humphrey, died in a sudden and alarming manner. Dr. Conant assumed charge of the laboratory, and, though aware of his own great danger, remained in Port Antonio, devoting himself to the service of others who needed his help. This generous subordination of self cost him his life, for he contracted the fever, and, though able to reach this country, he died a few days after his arrival in Boston.

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Dr. Conant's many friends, well aware of his candid, judicial mind, his keenness and persistency in observing and in reasoning from observations to a conclusion, have entertained the highest expectations of the work he was to do for science. Cut off at the beginning of his career, he leaves behind him several smaller papers and the dissertation before us. On closing this volume the author's friends will feel confirmed in their high opinion of his abilities, and those who did not know Dr. Conant will realize with regret that an able and conscientious naturalist has been removed from our midst.

Dr. Conant's dissertation. published as a memorial volume by his friends, fellow students and instructors, with the aid of the university in which he had recently taken his doctor's degree, deals with the anatomy and classification of one of the most interesting groups of jelly-fish, the Cubomedusæ. In this group, embracing but a small number of species, the scyphomedusan structure, with which most of us are chiefly familiar through the study of *Aurelia*, *Cyanea* or *Dactylometra*, is in general presented as destitute of the complications which characterize the more common forms. This simplicity in general structnre places the group close to the stem-forms, *Tessera* and *Lucernaria*, themselves scarcely more than sexually ripe *Scyphistomas*, and makes a comparison with existing Actinozoa an easy matter. Curiously enough, the members of this primitive group possess the most highly developed sense-organs as yet described among coelenterates, the nervous system being correspondingly differentiated. In one other respect the Cubomedusæ are unique, in that they alone among the Scyphomedusæ possess a velum. The phylogenetic origin of this velum (velarium) has been the subject of some discussion, the balance of opinion inclining to the belief that it has arisen through the fusion of marginal lobes similar to those

found in the Peromedusæ and the Ephyropsidæ (*Nausithoë*), and is merely analogous to, not homologous with, the velum of the Hydromedusæ. That this is the case is borne out by the presence in the velum of gastrovascular diverticula. This resemblance to the Hydromedusæ is regarded by most naturalists as one of the numerous cases of convergent evolution exhibited by the two groups of jelly-fish (Hydro- and Scyphomedusæ), due to similarity in environment and to a certain similarity in the ancestral polyps from which the two groups have been derived.

The Cubomedusæ are so rare that in spite of their interesting features, interesting alike to the student of phylogeny and nerve-physiology, few naturalists have had the opportunity of studying them. Our knowledge of the group has rested mainly on Claus's description of *Charybdea marsupialis* (Wien. Arb. 1878). This very valuable paper, as Conant remarks, is written in a style difficult of comprehension, and many students who read with pleasure and profit the lucid treatises on medusan structure by the Hertwigs and Haeckel have turned away discouraged from Claus's work. To Claus's account, Haeckel in his "System" has added but little. The only other investigator of the group is Schewiakoff (1889), who has studied the remarkable sense organs.

Through Conant's discovery in 1896 of two new species (*Charybdea Xaymacana* and *Tripedalia cystophora*), which are present in abundance in Jamaican waters, the Marine Laboratory of the Johns Hopkins University has once again made accessible to students, material for the pursuit of investigations of wide interest. It was for the purpose of continuing his study of this group that Conant, in the summer of 1897, revisited Jamaica, and, as we learn from Professor Brooks's introduction, he succeeded in making many observations on the physiology of the

sense-organs and on the embryology. His notes and material, we are told, are in such shape that they can be handed over to some else, and it may be safely predicted that a valuable contribution to science will be the outcome of the last summer's work of this talented young naturalist.

The account of the cubomedusan structure given by Dr. Conant is succinct, but comprehensive. The deep, four-sided bell bears a tentacle (or in some species a bunch of tentacles) at each angle. On each lateral surface, at a higher level than the tentacles, is situated a niche into which projects a sense-organ. The primitively undivided (Scyphistoma condition) gastrovascular space is here differentiated into a central stomach and a peripheral portion lying in the lateral wall of the bell. The peripheral portion is subdivided into four stomach pockets by linear partitions, lying in the plane of the tentacles and therefore interradial. These partitions (cathammæ) are mere strips of entodermal lamella, produced by the fusion between the entodermal lining of ex- and sub-umbrella. The cathammal lines stop short of the tentacles, leaving an undivided peripheral portion of the primitive space, by means of which the four stomach pockets communicate with one another. As Conant points out, the arrangement recalls the gastrovascular system of many Hydromedusæ, with the difference that in the Cubomedusæ the radial canals are wide 'stomach pockets' and the cathammal plates are narrow lines. When we come, however, to the extreme peripheral portion of the gastrovascular system, we find that the likeness is not with the Hydromedusæ, but with the lobed Scyphomedusæ. The gastrovascular space, to be brief, does not end with an even circular edge at the bell margin, as is the rule in the former group, but is divided into separate lobes (marginal

pockets) extending into the velum (as velar canals). Conant does not dwell on phylogenetic inferences, but evidently inclines to the belief that the ancestors of the Cubomedusæ possessed a margin divided into sixteen lobes. The present position of the four sense organs indicates the site of the original margin, "which elsewhere has grown down and away from its former level, leaving the sensory clubs like floatage stranded at high-water mark." Fusion between adjacent lobes, involving the ectoderm and jelly, gave to the medusa a continuous margin and a 'velum', but, owing to the incompleteness in the fusion of the *entodermal linings* of the several lobes, the latter still retain in the adult Cubomedusa enough of their individuality to indicate their former condition. In a word, the marginal pockets of the existing Cubomedusæ are to be construed as entodermal linings of once separate lobes.

This conclusion as to the morphology of the marginal pockets derives much support from the behavior of a puzzling structure, called by Conant the marginal lamella. Unlike the true vascular lamella, which simply connects one entodermal cavity with another, the marginal lamella extends from the entoderm of the gastrovascular space to the ectoderm of the bell margin. It is a narrow strip which follows the outline of the marginal pockets, traveling in the radii of the sense organs far away from the actual edge of the bell, and surrounding the sense organs in such a way as to indicate clearly that they were once at the bell margin. The marginal lamella seems to be a functionless, rudimentary organ. Claus, whose imperfect description of the structure did not bring to light its morphological interest, as indicating the site of the ancestral bell margin, suggested that it was perhaps the vestige of a ring canal. Conant naturally is skeptical of this explanation of a lamella connecting ento- and ectoderm. The true meaning of this peculiar lamella is a

point well worth working up, more especially as it is not confined to the Cubomedusæ, but has been observed in the ephyra lobes of discophores (*Rhizostoma*).

Before leaving this subject of the general body-plan, it may be mentioned that while the probability is that the Cubomedusæ are descended from stalked ancestors (*Lucernaria*-like forms), and hence that the apex of the exumbrella was once drawn out into a peduncle, there is in the adult Cubomedusa no trace externally or internally of this hypothetical stalked condition. Light on this very interesting point can only be expected from a study of the development.

Unlike the other Scyphomedusæ studied, the Cubomedusæ possess a nerve ring. In their study of the nervous system Claus and Conant both depended on sections, and naturally the results are not so satisfactory as those reached by the Hertwigs on the Hydromedusæ mainly with the aid of macerations. Claus describes the neuro-epithelium as consisting of alternating supporting cells and sensory cells, the inner ends of the latter becoming continuous with the nerve fibres. Conant makes it doubtful whether this is the actual condition, since he does not find the sensory cells. He offers, however, no observations on the origin of the 'nerve fibres.' Macerations will probably show the connection of these fibres with at least some of the neuro-epithelium cells.

The possession of a nerve ring has been regarded (Claus) as a point of essential similarity between the Cubomedusae and the Craspedota. The main ring in the former group is obviously a differentiation of the subumbrellar epithelium, and Claus, therefore, interprets it as homologous with the inner Craspedote ring. In the immediate neighborhood of each sense organ there are given off from the main ring two roots which *ceasing to be superficial bands* pass through the jelly, and emerge on the outer wall

of the bell (on the floor of the sensory niche). They converge and unite, forming a superficial nerve tract which crosses the base of the sense-club. These four isolated tracts are regarded by Claus as the remnants of a once continuous exumbrellar ring, such as is found in the Hydromedusae. and which here, as in the Hydromedusae, stands in connection with the subumbrellar ring through the medium of fibres that perforate the jelly. Conant, on the other hand, regards the tracts lying across the bases of the sense organs as portions of the primitive subumbrellar ring which were shut off from the main ring, when the marginal lobes grew together. With the Hertwigs and Haeckel he thus looks on the ring as not homologous with that of the Craspedota, but as a special differentiation of the subumbrellar plexus found throughout the Scyphomedusae.

The sense organs of the Cubomedusae are 'sense-clubs' or modified tentacles. In addition to the crystalline sac, the expanded head of the club bears six eyes. Four of these are simple, but two are complex organs provided with a cellular lens and cornea, a vitreous body behind the lens, and a retina. These eyes look into the bell cavity. It is especially in reference to the structure of the retina and vitreous body of the complex eyes, that Conant's conclusions differ from those of Schewiakoff. The vitreous body Conant finds is not a homogeneous structure, but is composed of prisms of refracting substance. The retina does not show the two types of cells (sensory and pigmented) distinguished by Schewiakoff. Conant's results in this matter of the retinal structure are in some respects negative. The points still to be cleared up are as in the case of the nerve cord, such as will require the free use of macerations and surface preparations of fresh tissue.

DISTRIBUTION OF WATERPOWER IN NORTH CAROLINA.*

BY J.A. HOLMES.

The two conditions essential to the development of a waterpower of any considerable magnitude are a large and fairly constant stream of water and a suitable amount of fall within a reasonable distance. In the eastern counties of North Carolina we have numerous large streams of water, but, except along the western border of the region, as a rule they have sluggish currents and are lacking in the necessary fall. In the mountain counties the streams are small, but the fall available in many cases is sufficiently great to make possible waterpower of considerable magnitude. It is in the middle counties, however, that we find the most satisfactory combination of the two essential conditions, viz. volume of water and fall; and hence it is in these counties that we may expect the largest waterpower developments and the greatest and most substantial growth of manufacturing enterprises.

It is intended in the present paper to discuss briefly the distribution of these water powers in the State in their relation to geologic features, and the accompanying map (Plate I) will prove of service in this connection.

WATERPOWER IN THE COASTAL PLAIN REGION.

Along the western border of the coastal plain region there are a number of important waterpowers, like those at Weldon on the Roanoke, Rocky Mount on the Tar,

*In part, reprinted in full from Bulletin 8, N. C. Geological Survey.

and those on the Cape Fear as far east as Averasboro. These, though they lie within the limits of this region, yet structurally do not belong to it, and can best be considered under the next heading below, in which will be discussed the waterpowers which belong rather to the border zone between the coastal plain and the Piedmont plateau regions, and which can perhaps be best designated as the fall line zone.

With the exception of the waterpowers just referred to, it may be said of the coastal plain region as a whole, that its waterpowers are of no great importance. The water supply is ample but the fall is lacking. And yet there exist at many different points in this region conditions which are favorable to the development of waterpower which, though small, have considerable local value. Until a comparatively recent date, practically all of the grist mills in this section were operated by small waterpowers, and a considerable number of these grist mills are still in operation. But such water waterpowers were confined to the smaller streams, and in many cases the development of power consisted simply in the construction of a dam across the deep, narrow channel of the stream without the existence of a natural shoal, and the amount of fall is approximately the height of the dam.

The most striking feature about the waterpower developed on the majority of these smaller streams is the slight extent to which the volume of water is effected either by the rains or dry seasons. The most widely known illustrations of this condition are Rockfish creek in Cumberland county, and Hitchcocks creek in Richmond county, both of which though small are industrially important streams. The former with a drainage basin of 280 square miles, running five cotton mills, and the latter with a drainage basin of 102 square miles running six cotton mills. The explanation of

this phenomenon is to be found in the fact that the deep, porous sands of the region serve as a sponge in soaking up the rains as they fall, turning loose this water gradually during the dry season through numerous springs.

In the case of many others of the small powers in this region, as that on Colly creek in Bladen county and others in the different eastern counties, the uniformity of the flow throughout the year is favored by the further condition that the tributaries of these streams pass through extensive swamp areas which also serve to store the water for use during dry weather.

WATERPOWERS IN THE FALL LINE ZONE.

Along the "fall line" or the fall line zone in North Carolina there are conditions favorable for the development of waterpowers of considerable magnitude on our larger streams. And since the exact position of this fall line is not clearly defined, and as the conditions favoring waterpower development extend across a considerable belt or zone where this line is crossed by the larger streams, it is better in this connection to consider together these conditions as they exist at and for a few miles on both sides of this boundary line between the coastal plain and Piedmont plateau regions.

ON THE ROANOKE RIVER.

The conditions favoring waterpower development on the Roanoke river in this zone, which at this point has a width of about 9 miles, extending up the river from Weldon, may be considered as typical of those existing other points. Waterpower developments of considerable magnitude are now in progress on the Roanoke and are being planned on the Cape Fear and Yadkin.

In portions of the coastal plain region, however, where the streams are cutting their way down across the horizontal and soft strata such as alternate beds of clay and sand, we have conditions somewhat similar to those described above except that in these cases the strata, instead of being alternate layers of hard and soft rocks, are of altogether unconsolidated materials which have not yet turned to stone. Such a condition of things may be illustrated by fig, 1, which represents somewhat the conditions existing on Rockfish creek in Cumberland county.

FIG. 1.

FIG. 1.—Interbedded sands and clays favoring the development of rapids in river channels.

P and P'—Finely laminated and in places cross-bedded, black laminated clay below, and bedded but cross-laminated clayey arkose above, the strata of both clay and arkose being separated by layers of sand varying in thickness from a small part of an inch to several feet. The strata marked P' above *rr* represent the same strata as P' below the *rr*. *s*—Sand hills back from the stream border. *t*—River terraces of recent loams, gravel at their base. *rr*—Surface of the stream showing that as it washes away the laminated arkose and clay, irregular rapids are produced in the stream, owing to the more rapid removal of the interbedded sand.

In the lower portion of its course the waters of this creek have cut their way through the overlying sands and loams and are now cutting through the lower interbedded sands, clays and arkose, and the still lower more finely laminated sands and greenish-black clays. Near the mouth of Rockfish these materials in its bed have been worn away to the level of the Cape Fear river

which it joins. Further back from the Cape Fear the cutting down through alternate layers of loose sand and tough clay has resulted in producing a rapid but irregular current with occasional small shoals, at several of which waterpowers have been developed by the construction of dams and factories erected.

Figure 2 may be considered as illustrating fairly well

FIG. 2.

FIG. 2.—Conditions favoring the development of cascades and rapids in stream beds crossing geologic contacts.

gn=Granite and gneiss. *sch*=Crystalline schists, in which the harder places (shaded more heavily) wear away less rapidly than the intervening softer places. The result is a series of cascades and rapids in the stream. *p*=Coastal plain deposits—gravel, sand and loam.

a generalized section across the fall line where crossed by the Roanoke river at Weldon. The crystalline schists exposed along the river bed between Gaston and Weldon (G and W of fig. 2) are much harder and more obdurate than the unconsolidated coastal plain deposits below, and even harder than the granite and gneissic rocks above it; and hence the latter rocks have been eroded to greater depths, and at the line of junction between the two (1 in fig. 2) the schists form a sort of barrier or natural dam, for many miles above which the river is deep and the current sluggish. But from this point down to Weldon the schists vary in hardness, and are intersected by joints, seams, fissures and probably sev-

eral faults; this succession of variations giving rise to a succession of rapids and shoals, with an aggregate fall of 85 feet in a distance of 9 miles. For this distance the river flows through a deep and open gorge flanked by hills which, near Gaston and a short distance westward, are capped with unconsolidated gravels, presumably of Potomac age, and bordered by terraces of more recent age, probably post-tertiary (Columbia). In the neighborhood of Weldon and eastward the rocky hills give places to the terraces and plains of the coastal region, composed of gravels, sand, loams and clays, varying in age from Potomac at the bottom to Columbia at the top.

ON THE TAR RIVER.

On the Tar river there is but one large waterpower, that at Rocky Mount, which may be considered as being at the eastern margin of this zone and some 20 miles eastward of the western border of the coastal plain region. The Tar rises nearly 100 miles to the northwest of this point and crosses successively several granitic, schistose and slaty belts of rock, but owing to the slight elevation of this upper part of its basin above that of the coastal plain, the long period during which the rocks of this upper basin have been undergoing surface decay, and the long period during which this stream, with no great volume of water, has been slowly carving out its channel, its freedom at the present rime from conditions favorable to waterpower is easily understood. At Louisburg there is a fall of several feet owing to a change in the character of the granitic rocks. At Rocky Mount it turns eastward and crosses a ledge of hard granitic rock, on the eastern slopes of which there is a natural fall of about 15 feet in the course of 100 yards. It is on the top of this granite ledge that the dam has been built which serves for the full development of this waterpower for operating the Rocky Mount cotton-mill.

ON THE NEUSE RIVER.

On the Neuse river, as on the Tar, there is rather a remarkable absence of conditions favorable the development of large waterpowers. Of the two powers worthy of mention, both lie within the granite area, one to the north and the other to the north-east of Raleigh, and are due to local changes in the character of the granitic rock.

ON THE CAPE FEAR RIVER.

The fall-line zone on the Cape Fear river may be said to begin where this river is former by the junction of the Deep and Haw rivers, and to extend from that point to a short distance below Smileys falls, near Averasboro. In this distance of about 35 miles there is a succession of shoals beginning just above with Buckhorn falls, 9 miles below the junction of the two rivers, where there is a fall of 20 feet in a distance of one and one-half miles, while the lowest of the prominent shoals, "Smileys falls," 30 miles below the junction, has a fall of 27 feet in a distance of three and one-half miles. The total fall from the junction of the two rivers to just below Smileys falls is about 100 feet. Within 17 miles below Smileys falls, by river, there are at least three different shoals, the last of which is only 8 miles above Fayetteville ; but none of them are of any importance, and they need hardly be considered in this connection.

The outlying gravels of the coastal plain deposits are to be found on the hills two miles to the west of the junction of the Haw and Deep rivers, so that all the shoals just mentioned lie within this region, and the sands and loams and gravels characteristic of the border deposits are exposed here and there in the river bluffs, though in the river channel these have been removed and the waters rush along over the upturned and irregular

eroded edges of granites and crystalline schists. Within a few miles above the junction of the Haw and Deep rivers both of these streams pass from the slates of the Piedmont plateau region to and across a narrow strip of Jura-trias sandstone, which latter is made up of materials far more easily eroded than the slates, and as might be expected there are shoals on both streams at this junction. The rivers join within this sandstone area, and for a few miles below the junction the Cape Fear is a sluggish stream.

ON THE YADKIN-PEE DEE RIVER.

On the Yadkin-Pee Dee river a condition of things exists somewhat similar to that on the Cape Fear just mentioned. The course of the Yadkin river as it crosses the slates, for some 15 miles above its junction with the Uharie, is briefly described further on. Below its junction with the Uharie the river flows for a distance of some 20 miles in a southerly course obliquely across and in places paralleling the upturned edges of the argillaceous slates. In this distance there are only two prominent shoals, but neither of great importance as compared with those at the narrows above. These are Swift Island shoal, 42 to 44½ miles above the state line, and Gunsmith shoal, 13 miles further up the river. Further down, the river flows easterly as a somewhat sluggish stream across a few miles of red sandstone rocks, similar to those crossed by the Cape Fear at the junction of its two tributary streams. It then enters the coastal plain region, near where it is joined by Little river and follows a southerly course via. Cheraw, 35 miles below. Throughout this distance there is a succession of shoals due to the fact that the river crosses the upturned and irregularly eroded edges of alternate beds of slaty and granitic rocks.

The river crosses the lower limit of the fall line zone a little above Cheraw. The shoals in the river at that point and for some distance above are not large, but they are sufficient to mark the passage of the river from its characteristics in the Piedmont plateau region to its typical coastal plain condition, that of a sluggish stream.

GEOLOGIC CONDITIONS FAVORING WATERPOWER DEVELOPMENT AT THE FALL LINE.

(1). The eastward tilting of the surface of these older crystalline rocks, and (2) the partial removal of the loose and easily eroded loams and gravels from the channel on the eastern slope of these rocks, have given this resulting descent in the river surface at the fall line, which, in the Roanoke at Weldon, aggregates 85 feet in 9 miles. (3) The variation in the character of the rock, being harder and more obdurate at certain points, and softer, more jointed, more crushed, and hence more easily eroded at the intervening areas, results in concentrating this fall of the stream at certain places; and (4) the existence of terraces along the river banks facilitates the construction of canals which still further concentrate the fall of the water. These are the more important geologic conditions that favor the development of important waterpowers on the Roanoke at the fall line in the Weldon region.

Other striking cases illustrating the conditions favoring waterpower development on streams crossing geological contacts will be found mentioned on pp. — and — of this report.

WATERPOWER IN THE SLATE BELTS.

One of the most common types of geological structure affecting waterpower development in North Carolina

and other south Atlantic states is that to be found in the great belts of slates and crystalline schists lying in the eastern part of the Piedmont plateau region. (See map). Here, as in structural type shown in fig. 3 below, layers or sheets of rocks are nearly vertical, and are composed of material varying in hardness and durability ; but throughout much of this belt, and especially along its western border, the variations are less well defined and on a smaller scale, the thin, hard layers being so numerous and so generally distributed that in the streams like the Haw and Deep rivers, which cross the larger portions of these belts nearly at a right angle, there is almost a continuous series of small rapids or shoals with an aggregate fall of from 5 to 20 feet to the mile.

The possibility of waterpower development on the Haw, Deep and Yadkin, as they cross the central and most extensive of these slate belts in Alamance, Randolph, Davidson, Stanly and Montgomery counties, is greater than on any other portion of these rivers.

ON THE HAW AND DEEP RIVERS.

Both the Haw and Deep rivers rise in the granitic and gneissic area, the former to the northwest and the latter to the southwest of Greensboro, and are sufficiently large in volume to be available for small powers by the time they reach the western border of the slate belt. Throughout their course of about 50 miles across it each river is a succession of shoals or rapids, many of which have already been developed, while a number of others are capable of being developed on a considerable scale. The slates and schists of this region have a general northeasterly course, and, as a rule, dip steeply toward the northwest, so that these streams with a southeasterly course have cut their beds directly across the upturned

edges of the slates, which vary in hardness and obduracy from point to point, the harder sheets projecting upward as ledges, and the intervening softer sheets being washed out as depressions, which thus give rise to the shoals and rapids.

ON THE YADKIN RIVER.

The Yadkin river strikes the slate belt some 12 or 15 miles below the Southern railroad crossing near Salisbury, and for a distance of 20 miles below this point the geologic conditions in this slate have resulted in a succession of shoals and rapids which promise to be of great value in connection with the development of manufacturing enterprises.

Where the Yadkin river crosses the larger of these belts of slates and schists there is a greater concentration of the hard and soft material, and consequently a greater concentration of fall in the river at certain points, than is described above as occurring on Haw and Deep rivers; yet on the whole this Yadkin river section, illustrated with approximate accuracy in fig. 3, may be considered as fairly typical for sections of country where these belts of rock exist. The space between 1 and 2 in the diagram represents the "narrows" section, a distance of nearly 5 miles. The rock is eruptive in character, though an obscurely bedded conglomerate at the upper (N.W.) side. It is all hard, but not uniformly so, being harder and more obdurate at certain places, arranged at intervals, producing the narrows rapids at the upper end (just below 1) and the "little falls" and "big falls" near the lower end (just above 2). The total fall from 1 to 2 is nearly 100 feet.

Below the narrows (between 2 and S.E. in fig. 3) the

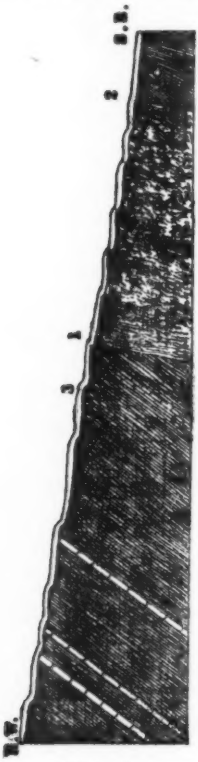

FIG. 3.

FIG. 3.—Conditions favoring the development of cascades and rapids in river channels crossing belts of inclined slates and crystalline schists.

a—Argillaceous slates dipping northwest, with harder and more durable layers at intervals (as at 3). *b*—Crystalline schists, mainly of volcanic origin, obscurely schistose, more massive and obdurate in places, as where the shading is heavier. *c*—Finely laminated and uniform argillaceous slate.

rock is mainly an argillaceous slate of fairly uniform character and easily eroded by water action; and the existence of this softer material beside the belt of hard, obdurate rock which itself is not uniform, but has harder and softer belts, affords just the conditions favorable for the development of rapids and cascades in the stream that crosses both belts. As might be expected, these harder rocks (*b* in fig. 3) cross the country in a high, irregular ridge, while the surface of the region to the southeast, occupied by the slaty and sandstone rocks, is less hilly and less elevated. The Yadkin crosses the harder ridge as a rushing torrent in a deep, narrow gorge—the "Narrows"—but as soon as it reaches the softer slaty rock (at 2 in fig. 3) the current slackens, the stream widens and flows on for several miles as a smooth and relatively sluggish current.

For several miles up-stream from the Narrows the rocks are mainly clay slates having a southwest-northeast course, and dipping steeply toward the northwest;

and so the sheets or beds of rock stand on edge and lean down-stream (S.E.). These rock beds are for the most part fairly soft and more easily washed away than other more massive and more durable layers which occur at irregular intervals, and consequently below these more massive sheets of rock are the shoals and rapids as indicated in figs. 2 and 3 above and as described further on.

WATERPOWER IN THE GRANITIC AND GNEISSIC AREAS.

The larger granitic and gneissic areas occupy the region from the western border of the slate belt just mentioned westward to the foot of the Blue Ridge, the typical Piedmont plateau section of the state.

In granitic and gneissic rock, the materials not being arranged in definite strata or layers, the exact conditions which cause the production of cascades and rapids in streams are less apparent than in the slaty and schistose rocks just described. The accompanying sketch (fig. 4) illustrates a few of the conditions favorable to the development of waterpowers in a region where these rocks prevail, as in portions of central and western North Carolina.

1. One often finds in such regions breaks, such as faults or joints in the rock, the material on one side of the break being somewhat crushed or sheared and hence easily removed. Of course the streams of water in crossing the section of country where these breaks or faults occur, and especially where the crushed or sheared side of the break is the lower side on a sloping surface, remove this lower side more rapidly than the upper and thus form a cascade from the higher to the lower level as seen at 1 in fig. 4. It is in that way that some of the beautiful falls of the southern Appalachian mountain re-

gion have been produced. Other cascades and shoals are developed under the following conditions:

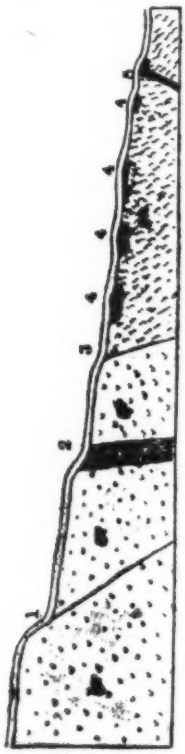

FIG. 4.

FIG. 4.—Conditions favoring the development of cascades and rapids in river channels crossing areas of granitic and gneissic rock. *gr.*—Granite. 1—Fault or break in the rock, the right side having moved down or the left side moved up. 2—A schistose zone in the granite resulting from the shearing or movement of the rock along a line of weakness. *gn*—Gneiss, in which there are alternately harder and softer portions, the harder and more obdurate places being more heavily shaded (as at 4). 5—Dike of diabase or other material harder and more obdurate than the gneiss, and never producing a cascade or rapid in the stream channel.

2. In portions of the granitic area there are lines of structural weakness where, under great strain or pressure, the materials of which the rock is composed give way and are flattened out by a process known as shearing, so as to give there a rather gneissic or schistose structure, as at 2 in fig. 4. The rock in this condition is often more rapidly attacked by the weathering and eroding forces of the atmosphere, and, consequently, as the streams cross the surface of the couutry where such conditions exist, they carve out their channels more rapidly, thus producing shoals or rapids, and, in extreme cases, cascades or falls.

3. Conditions somewhat similar to the above and favorable to the formation of shoals and rapids in streams are sometimes found along the line of contact between areas of granites and gneisses, as at 3 in fig. 4; and

again in gneissic areas in places the rocks are harder and more obdurate, as indicated by heavier shading at 4 in fig. 4; and in the beds of streams crossing such areas the rocks wear away irregularly, the harder portions standing out as projections while the intervening softer materials are hollowed out. In this way we have produced a succession of shoals, a few hundred yards or several miles apart; and between these are to be found the quiet reaches of the streams where the current moves along more smoothly and quietly.

4. Another structural feature in granitic and gneissic areas, and also in slaty and sandstone areas, which occasionlly results in the production of the shoals and rapids, is the occurrence of dikes, where cracks in the earth's crust have been subsequently filled with various materials in a plastic and usually a molten condition and which materials have subsequently hardened. If the material of the dike is softer than that of the granitic or gneissic rock on one or both sides of it, then there will be a drop in the course of the stream from the adjoining rock of the wall down on to the softer dike surface, as is shown at 2 in fig. 4. If on the other hand the material constituting the dike is harder and more durable than the materials on each side of it, the country rock on the lower side of the dike, owing to its being softer and less durable than that composing the dike itself, will wear away more rapidly than the material of the dike, and consequently the water will drop from the dike surface on to the country rock below it, as indicated at 5 in fig. 4 above. The occurrence of the belt of eruptive rocks between the two belts of slate, as shown in fig. 3 (p. 103), may be considered as analogous to this last-mentioned case. On the Deep river near Gulf and on New Hope creek, a tributary of Haw river, are to be found illustrations of the development of waterpower being favored by the oc-

currence of diabase dikes in the Jura-trias sandstone crossing the channel of the stream.

ON THE YADKIN AND CATAWBA RIVERS.

The conditions favoring the development of waterpowers in granitic and gneissic areas have been described very briefly above, and the cascades and shoals and rapids on the Yadkin and Catawba, as well as on the tributaries of the Broad, will generally be found to have their origin in local changes in the character of the rock, in one or another of the ways there suggested. All of the conditions there described are to be found illustrated at intervals in this region.

As will be seen the shoals on the upper Yadkin, which lie within the area now under consideration, are less numerous than those on the same stream in its course across the belt of slate and schist already described. And inasmuch as the changes in the character of the rock in the region of the upper Yadkin are for the most part not radical, the amount of the fall at each of the shoals is less great than in the slate belt. This fact, together with the diminishing volume of water as we ascend the stream, render the powers on the upper portions of this stream less important.

The Catawba river, which, like the Yadkin, rises along the crest and eastern slope of the Blue Ridge, flows nearly a hundred miles in a northeasterly course and then turns southward. Its course in North Carolina lies entirely within the gneissic and granitic area. From Morganton eastward for a distanca of nearly 40 miles the river either parallels the general strike of the rocks or crosses it obliquely. The changes in the character of these rocks are not numerous, and the number of shoals correspondingly small, though several of them are of considerable magnitude. The river then runs in a south-

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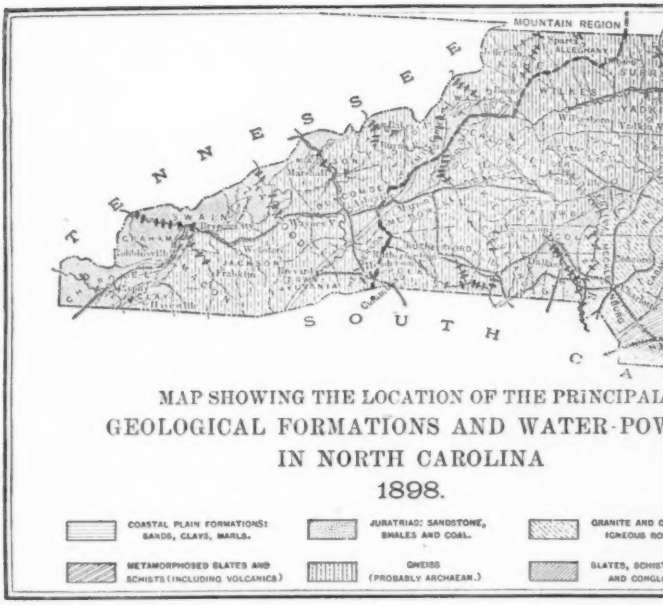
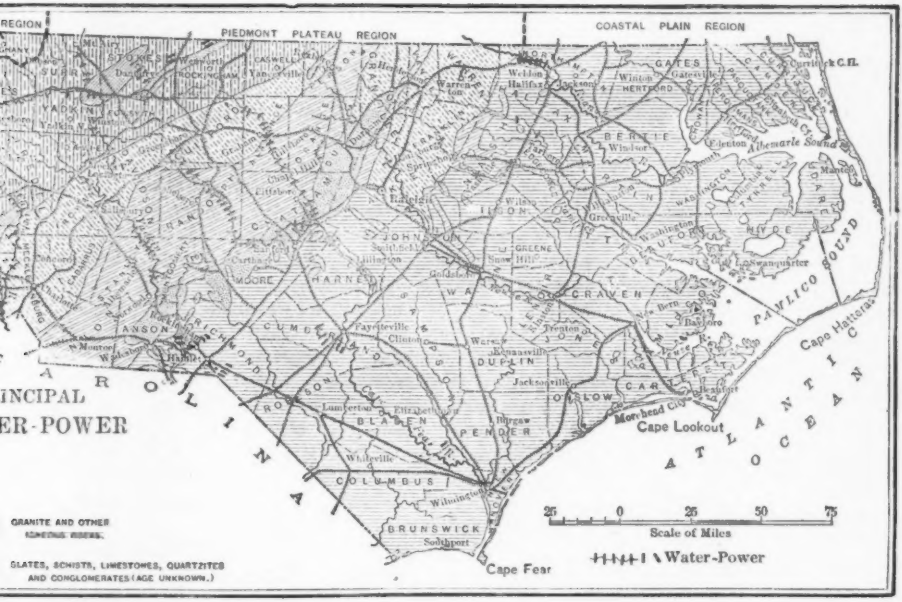


MAP SHOWING THE LOCATION OF THE PRINCIPAL
GEOLOGICAL FORMATIONS AND WATER-POW
IN NORTH CAROLINA
1898.


REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
INCIPAL
ER-POWER
GRANITE AND OTHER
SLATES, SCHISTS, LIMESTONES, QUARTZITES
AND CONGLOMERATES (AGE UNKNOWN.)
Cape Fear
Cape Lookout
Cape Hatteras
Albemarle Sound
PAMLICO SOUND
ATLANTIC OCEAN
Morehead City
Scale of Miles
Water-Power

easterly and southerly direction for a distance of but little more than 25 miles; but in this distance it crosses the course or strike of the rocks at right angles. The changes in the character of the rocks are numerous, the rocks even being schistose and slaty in places and the stream is literally a succession of shoals, the aggregate fall being not less than 175 feet. At a point some 10 miles south of Statesville, as will be seen on the small map, the river reaches the typical granite belt of this region and flows thence southward for a distance of approximately 40 miles, where it crosses the state line into South Carolina. In this part of its course the rocks of the region are again more nearly uniform, and though there are several shoals of importance, as those at Cowans ford, Mountain Island, and Tuckaseegee, yet the number of these shoals in proportion to the distance is much smaller than in the 25-mile section next above.

ON THE TRIBUTARIES OF BROAD RIVER.

Among the tributaries of the Broad in Cleveland and Rutherford counties, the streams descend rapidly from the South Mountains along the upper border of these counties down to the general plain of the Piedmont plateau, flowing in a southerly and southeasterly direction nearly at right angles to the general strike of the rock, and in this way encountering the greatest number of changes in the character of these rocks, which results in conditions most favorable for the development of waterpower. Hence it is that we have in this region a large number of valuable waterpowers, some half dozen of which are already operating cotton-mills, while others are soon to be utilized in the same way.

CONDITIONS IN THE SLATY AND GNEISSIC AREAS COMPARED.

In any study of the streams and waterpowers of the

Piedmont plateau region it should be borne in mind that while the slaty belts present more favorable conditions for developing waterpowers, as shown in the case of the Yadkin and the other streams which cross the several belts, owing to the fact that in these belts the sheets of rock stand more on edge and vary more in hardness and durability, yet the streams which draw their supplies from the granitic and gneissic areas are more uniform in their flow for the reason that while the rainfall in the different belts is approximately the same, the soils in the granitic and gneissic areas are deeper and more porous and serve more as a sponge for storing up the surplus water of rainy seasons than does the more shallow and compact clayey soils resulting from the decay of the slates. This is one of the principal causes why the flow is less uniform in the case of the Haw and Deep rivers (see map), which lie largely in the slaty belt, than in the case of the Yadkin and Catawba, which lie almost wholly in the granitic and gneissic areas. Fortunate it is then, that these two larger rivers have their headwaters in the granitic and gneissic areas, with gravelly, porous soils; and flow across the great slate belt after they have attained their larger proportions.

WATERPOWER IN THE MOUNTAIN REGION.

A glance at the accompanying small geologic map will show that the larger part of this region is occupied by gneissic rocks. These have for the most part a characteristic northeast and southwest strike, and the irregular sheets of rock dip beneath the surface at varying but generally steep angles. The southern half of the region has along its western border an irregular belt of bedded slates, limestones, quartzites and conglomerates; and these rocks, which make up the bulk of the Great Smoky mountains, have a general north-

easterly strike and dip at steep and varying angles. Near the eastern border of the region there is another but more narrow and irregular belt of rock of a somewhat similar character, following approximately the general position of the Blue Ridge mountains.

The general physiographic features of the region are those mountains and hills with narrow valleys. It may be restated here that the rivers of this region have their sources mainly along the western slope of the Blue Ridge, and that with the exception of New river, near the northern boundary, they flow in a general northwesterly direction across the upturned edges of both the gneissic and the more recent bedded rocks. The elevation of the country is so great and the descent of the streams so rapid that the general courses of the principal rivers have been but little modified by geologic structure, though their courses lie directly across the strike of the rock; and the resulting conditions are such as to produce along the streams occasional rapids and cascades. Especially would this be the case in the western counties, where the Pigeon, the Tuckasegee, the Little Tennessee and the Hiwassee break through the Great Smoky mountains, and in doing so cross a variety of limestone, quartzite and conglomerate beds which go to make up the geologic formation of that area, but for the fact that during the long period of time that these streams have occupied their present channels, owing to the rapidity of their flow and the large quantities of abrading materials, such as sand, gravel and bowlders, carried down in their currents, the variations in the obduracy of the rocks, crossing these stream beds seldom result in cascades of large proportions, for the reason that the would-be projecting ledges of rock across the stream bed are kept down near the general level by these eroding agencies.

A number of the smaller tributary streams flow in either

a southwesterly or a northeasterly direction along the line of the strike of the rocks and thus develop the conditions favorable for waterpower, mainly where they vary their courses and cross from rock of one character to one of a different character. In the extreme northern portion of the region the tributaries of New river rise both on the western slopes of the Blue Ridge and the eastern slopes of the Iron mountains, and flow in a general northeasterly or northerly direction, sometimes following the line of the strike, and sometimes crossing the latter at sharp angles. Along New river and its tributaries are a number of shoals which can be developed into valuable waterpowers, occuring mainly at points where the streams cross the strike of the gneissic rock of the region.

In connection with the development of these waterpowers, the river gorges are so narrow and the streams so rapid that while the construction of large dams is a matter attended with no insurmountable difficulties, yet it is often difficult to find suitable space for buildings, and it has been found more advisable in a number of cases to construct small dams and to convey the water from these in open ditches or flumes along the banks of the stream to suitable points where the power may be utilized. The chief difficulty which is met in storing water on these streams is that the ponds or storage reservoirs become rapidly filled with sand, gravel and bowlders brought down in time of flood. Probably the future development of these powers will be largely in connection with electrical transmission.

GEOLOGICAL CONDITIONS AFFECTING THE FLOW OF STREAMS.

The yearly discharge of a stream depends primarily on the amount of rainfall in the region from which the stream draws its supply, but in a measure this volume, and especially the uniformity of flow, are largely in-

fluenced by the slope of the surface, the depth and porosity of the soil, and the character of the underlying rock. In connection with this study of the geologic conditions influencing the possibilities of waterpower development, it should be noted that the occurrence of lakes, swamps or marshes and poorly-drained level areas, deep and porous soils, such as the sandy and gravelly soils from 10 to 100 feet deep, which occur in the larger part of the Piedmont plateau and mountain regions of the Carolinas, the great sand hills of the southern coastal plain region, and the porous sands and gravels of the glaciated regions of the Northern states, all facilitate the uniformity of the flow of the streams in these several regions; and in some regions the jointed, fissured and crushed condition of the underlying rock exerts a favorable influence in the same direction.

NOTES ON GRASSES.

1) CONTRIBUTIONS FROM MY HERBARIUM. NO. IV.

W. W. ASHE.

Since the publication of a paper on the Dichotomous Group of Panicum in the Eastern United States (in this Journal, vol. xv, Nov., 1898) I have found among some duplicates additional material of a plant, a single specimen of which I had at that time, but such scanty material that I did not care to base a species on it, though it

1) Issued April 20, 1899.

showed excellent specific characters. I find that I have collected the plant at two stations, both in Orange county, N. C.

PANICUM ORANGENSIS, sp. nov. Stems 12 to 24 inches long, ascending from a geniculate base, pubescent with long, soft, white, matted hairs, but more or less glabrate towards the top. Lower sheaths crowded and overlapping, pubescent with soft matted hairs; the upper distant and nearly glabrous. Leaves soft-pubescent like the sheaths, the largest 3 to 4 inches long and 3" to 5" wide, lanceolate, long taper-pointed, largest near the base of the stem; the upper much reduced and often glabrous. Ligule pilose with long hairs. Panicle long-peduncled, oblong, the very numerous, slender fascicled branches ascending; spikelets scarcely $\frac{3}{4}$" long, obovate, apiculate, the first scale about one-third as long as the glabrous 7-nerved second and third.

Related to *Panicum lanuginosum* Ell., and separated from it by having a longer, softer pubescence and its leaves not being ciliate. Collected in June, 1898.

As the name *Panicum commelinaefolium* proposed by me (Mitchell Journ. 15, part 1; 29) for a Georgia plant has already been used by Kunth for another grass, I propose the name *Panicum Currani* for my plant; and for *Panicum Georgianum* Ashe (ibid, 36) I propose the name *Panicum Cahoonianum*, since Sprengel has made use of the nearly similar *P. Georgicum* for a different plant.

ANDROPOGON GYRANS sp. nov. Stem very slender, 18 to 24 inches high, glabrous or merely bearded at the upper joints. Basal leaves 10 to 14 inches long, 1" wide or less, glabrous, often involute and twisted, those of the stem much shorter. Sheaths glabrous. Branches very few, scarcely protruding from the closely wrapped sheaths. Spikes 2 or 4, generally 4, very slender, 6 to 12 flowered, spikelets $1\frac{1}{2}$" long, shorter than the copious, white, basal hairs; sterile spikelets of single scale, cov-

ered with long spreading hairs, as well as its slender pedicel.

Distinguished from A. *Elliotii* and all the slender forms of that species, by the much smaller spikelets, scattered branches and narrow sheaths, which do not enlarge.

Collected by the writer in pine woods in Durham county, N. C., Oct. 1896.

ANDROPOGON MOHRII PUNGENSIS, var. nov. Less tomentose than the type. Spikes generally more numerous, 4 to 12, and shorter, enclosed in the sheaths or protruding.

Collected by the writer in grassy swamps at the head of Pungo river, Washington county, N. C., Oct. and Nov., 1898.